JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES
VOL. VIII MARCH 19, 1918 No. 6

OCEANOGRAPHY.—*An electrical instrument for recording sea-water salinity.*[1] ERNEST E. WEIBEL and ALBERT L. THURAS, Bureau of Standards. (Communicated by S. W. Stratton.)

The modern tendency in physical research is to replace indicating instruments by recording instruments wherever possible. This has been especially true in the science of meteorology, where the recent advances have been brought about almost entirely by the remarkable improvements and developments in recording instruments. In the related science of oceanography there are practically no recording instruments now in general use, except possibly the tide-gage. If meteorology has been so greatly benefited by such instruments, surely in oceanography, where the changes in the physical properties are so much more regular and therefore more easily interpreted, great advances should be looked for through the addition or substitution of recording instruments.

A few years ago a recorder using a platinum resistance thermometer,[2] giving a continuous record of the surface temperature of the ocean, was designed and constructed at the Bureau of Standards. This instrument has been used successfully on board ship and some very interesting records have been obtained which show the distribution of temperature and thereby indicate the location of ocean currents and also give a knowledge

[1] Done under the auspices of the Interdepartmental Committee on Oceanography, subcommittee on instruments, apparatus, and measurements.

[2] WAIDNER, DICKINSON, and CROWE. Bureau of Standards Bull. 10: 267. 1914.

of their boundary conditions which could hardly be obtained by repeated single measurements of temperature.

The temperature, however, is not nearly so reliable a clue to the location of currents and the origin of water masses as is the salinity. A body of sea water may change considerably in temperature in moving from one place to another, but unless the evaporation or rainfall is excessive its concentration will change comparatively little. By salinity is meant the number of grams of salt or solids in one kilogram of sea water. The composition of these salts is very nearly constant everywhere in the open ocean, but the salinity, or concentration of the total salts, varies from place to place.

From a consideration of the properties of sea water that vary with the salinity, the electrical conductivity seemed to be the most susceptible to continuous measurement, if the difficulty due to the variation of conductivity with temperature can be overcome. This difficulty is avoided by the use of a method which is compensated for temperature.

This paper describes the method of measurement and the experimental work done towards the production of an apparatus to give a continuous record of sea-water salinity to the accuracy required in the most precise oceanographic research. The work has not been finished, but from the results obtained we believe that the method is practical and sufficiently important to warrant publication at the present time, even though the apparatus is not yet built.

DESCRIPTION OF THE METHOD

The method consists in measuring the ratio of the resistance of sea water in two equal or nearly equal electrolytic cells *A* and *B* (fig. 1); one cell *A* is sealed and contains sea water of a known average salinity, the other cell *B* is open and has flowing through it the sea water to be measured. This ratio is obtained by a Wheatstone bridge using alternating current to eliminate polarization effects in the cells. A calibration of the apparatus can be made at any time by using sea water of known salinity in the

open cell. This can be done either by carrying standard samples or by determining the salinity of the sea water flowing through the open cell by some accurate method that can be used on board ship. Such a method giving salinity by a measurement of density has been described.[3] A record of the resistance ratio of the two cells is made by a recorder similar to those now in use for measuring temperature, but some changes will have to be made to adapt it for using alternating current.

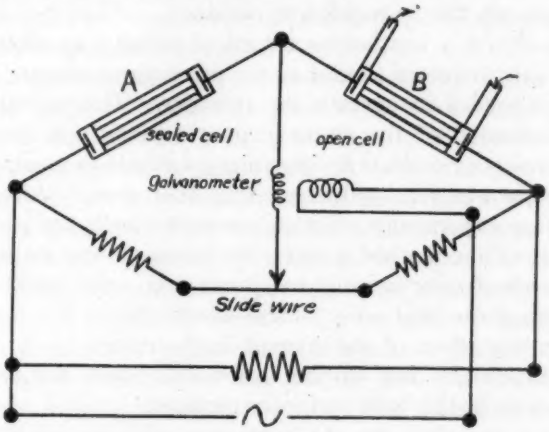

Fig. 1.

The new and important feature of this method is the use of two cells containing liquids of nearly the same properties, which make it possible to compensate almost completely for the large temperature coefficient of sea water. The two cells are placed in a uniform temperature bath and the error will be only that due to the small differential temperature coefficient of the two solutions.

EXPERIMENTAL WORK

Preliminary experiments to test the general feasibility of the method showed:

1. Good balances can be obtained with a simple Wheatstone

[3] THURAS, A. L., Journ. Wash. Acad. Sci. 7: 605. 1917.

bridge circuit containing the two electrolytic cells, using either a telephone at 500 cycles per second or an alternating current galvanometer at 60 cycles per second as a detector.

2. The temperature compensation is sufficient. For the maximum difference in salinity the lack of compensation did not exceed 0.03 in salinity (0.03 gram of solids per kilogram of water) for a change of 10°C.

3. No appreciable change in balance due to the flow of the sea water through the open cell was obtained.

4. To obtain a continuous record of salinity an alternating-current galvanometer similar to the usual direct-current galvanometer is needed to operate the recorder. This galvanometer was constructed of the electromagnet moving coil type,[4] and had a sensitivity and other operating constants as good as those of the direct-current galvanometers now used. After these preliminary experiments on some temporary cells had shown the feasibility of the method a more careful study was made of certain sources of error in order to obtain data upon which to base the design of the final cells. These effects are:

1. Heating effect of the current in the cells;

2. Temperature lag of the sealed cell when the sea-water temperature in the bath suddenly changes;

3. Time necessary for the resistance ratio to reach its true value if the sea water passing through the open cell changes in salinity.

In the ordinary conductivity measurements performed in a laboratory the heating effect of the current can be made negligible by using a sufficiently sensitive galvanometer or telephone receiver, but with the less sensitive recording galvanometer this current must be much larger and consequently requires a specially designed cell to dissipate the heat developed. From experiments on differently shaped cells the heating coefficients, i.e., temperature rise per watt dissipated in the cells, were found to be approximately inversely proportional to the diameters and lengths of the cells. Since the length of cell is limited by

[4] WEIBEL, E. E., Bureau of Standards Sci. Paper No. 297, p. 23. 1917.

practical considerations, it was necessary to increase the diameter in order to reduce this coefficient.

To determine the temperature lag, different cells were placed in a stirred bath and their time constants were found by changing their temperatures slightly from the temperature of the bath and reading the resistance at definite intervals as the cell gradually assumed the temperature of the bath. By time constant is here meant the time necessary for the temperature of the cell to approach the temperature of the bath to 67 per cent of its initial difference in temperature.

The time constants were found to be very approximately inversely proportional to the square of the diameter of the cells. Therefore the condition that is required to reduce the heating coefficient is opposite to that which will reduce the time constant, and since both of these values must be small special *multiple tube* cells were designed which will fulfill these conditions.

The time lag produced by a change in concentration of the sea water was determined by passing water of different salinities through a cell and it was found that if the cell is being swept out at the rate of three or four volumes a minute the ratio will respond within three or four minutes for probably the maximum change in salinity which can occur. The following considerations will show the purpose of reducing these factors as much as possible.

In general the temperature and salinity of the ocean changes very gradually from place to place so that usually no special cell would be required to record the salinity, but at some places as for instance in the vicinity of the Grand Bank of Newfoundland, where the cold fresh water of the Labrador Current meets the warm salty water of the Gulf Stream, the temperature and salinity change comparatively rapidly in moving from one body of water to the other. At these places such a specially designed cell is necessary. A few years ago a number of temperature records of the ocean were taken from a vessel going at moderate speeds and the most sudden change in temperature was 3.5° in about one minute. If this change is assumed to be instantaneous, the temperature of the sealed cell will in less than two min-

utes be so near that of the open cell that the error will be less than 0.02 in salinity.

Although there are as yet no observations on the rate of change of salinity, it is assumed that the maximum change in a short interval of time is not greater than 2 in salinity. This value is estimated from the relative changes of temperature which are discussed above. A response to this change to within 0.02 in salinity in less than two minutes can be obtained by washing out the cell at the rate of 3 or 4 volumes a minute. However, if the temperature and salinity change at the same time, which is

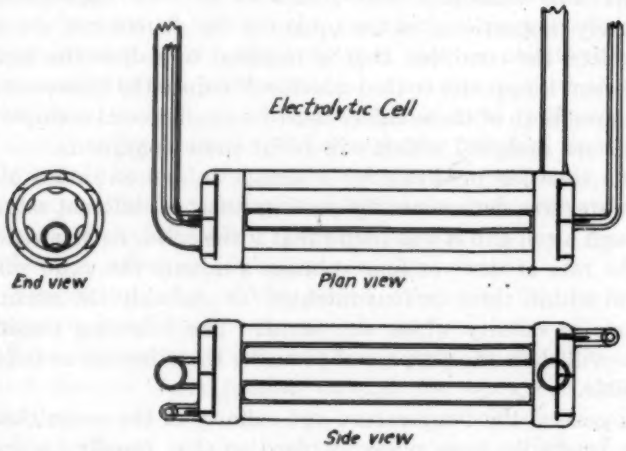

Fig. 2.

quite probable, the lag of the recorder will be the sum of the two and if they are both a maximum at the same time, which is quite improbable, then the total time lag will be 4 minutes. This is probably the worst possible condition that can occur, but it is well to point out that as the regain of the true reading is exponential the recorder will at first quickly approach its correct value and although it takes four minutes to reach within 0.02 in salinity it will take much less than two minutes to obtain an accuracy of 0.04 in salinity. However, if a more careful study of the change in salinity between different water masses

is required it is only necessary to increase the flow through the open cell and to make a correction for the error caused by the rapid change in temperature. Since another recorder will be used to measure the temperature of the sea water this temperature correction for the salinity can easily be obtained.

MULTIPLE TUBE CELLS

Each of the 2 cells that have been designed (fig. 2) contains 6 parallel glass tubes 14 cm. long and 1 cm. in diameter. These tubes are joined at each end to bulbs containing annular-shaped platinum electrodes. Each electrode has an area of 5.3 sq. cm. and is held rigidly in place by 4 platinum pins which are welded to the electrode and sealed into the glass wall of the cell. The cells are designed so that there are no pockets in which air can collect, and the sea water is admitted in such a manner as to sweep off any bubbles that might collect on the electrodes. The inlet and outlet tubes are sufficiently large to insure a thorough washing out of the cell in sufficient time to respond to the maximum changes in salinity that are liable to be met with on a vessel running at moderate speed.

RECORDER

In order to obtain a continuous record of sea-water salinity the Wheatstone bridge and galvanometer must be embodied in a recorder mechanism such as that developed by the Leeds & Northrup Company. The most important changes in their present recorder are due to the use of alternating current. The electrical connections are as shown in fig. 1. The current may be obtained from the usual 60-cycle supply, but if only direct current is available then the small direct-current motor used for driving the recorder mechanism can be equipped with slip rings and be operated as a converter. The recorder paper should be ruled so that salinities can be read directly.

INSTALLATION AND OPERATION ON BOARD SHIP

To obtain a continuous record of surface salinity, the apparatus will be set up similarly to the temperature-recording appara-

tus previously used.[5] The recorder will be properly secured in a convenient place on the vessel and insulated wires will lead from it to the cells. The cells (see fig. 3) will be mounted close together in a bath through which water direct from the ocean will flow continuously. This will insure a uniform temperature throughout the bath. A flow of water will also be maintained

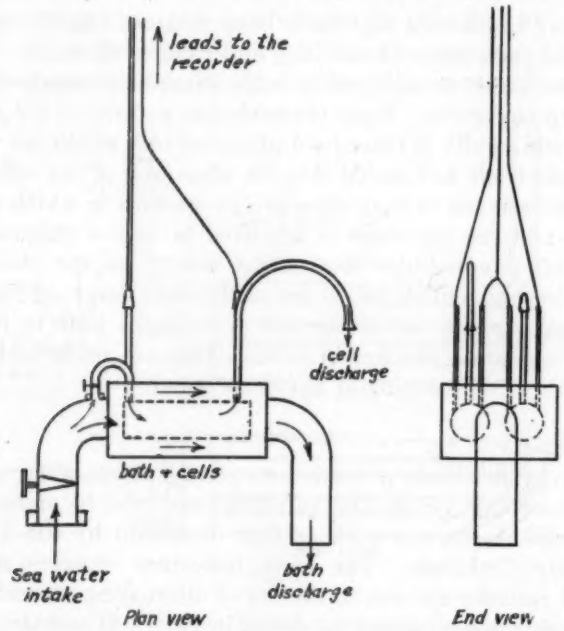

Fig. 3.

through the open cell, this water being tapped off from the main supply which passes through the bath. This flow must be broken as it leaves the cell in order to eliminate the resistance error due to shunting the open cell. The bath and connections to the sea-water supply will be carefully covered with heat insulating material to insure a uniform temperature throughout.

[5] Treasury Dept., U. S. Coast Guard Bull. 5: 27. 1915.

SUMMARY

An apparatus to give a continuous record of sea-water salinity by the measurement of its electrical conductivity is described. A pair of electrolytic cells has been designed which when used with a suitable alternating-current galvanometer will give satisfactory operation in connection with a recorder. The temperature compensation is obtained by placing both cells, which are in the two arms of a Wheatstone bridge, in a uniform temperature bath.

ETHNOBOTANY.—*The maho, or mahagua, as a trans-Pacific plant.* O. F. Cook, Bureau of Plant Industry, and Robert Carter Cook.

As noted previously in this Journal[1] the word *cumara* or *kumara*, a name for sweet potatoes, is found in the Pacific islands and among the Quichua Indians of the interior valleys of southern Peru, on the eastern slopes of the Andes. Considering the plant as a native of America, the preservation of an American name among the Polynesians appears significant. If the sweet potato and its name were carried into the Pacific in prehistoric times, other evidences of communication may be discovered.

The underlying question is whether agriculture and civilization arose independently in the two hemispheres, or had their early development in America and reached Asia by way of the Pacific islands. Did civilization grow from a single primary root, or were there parallel developments among widely separated peoples? The agriculture of ancient America undoubtedly was indigenous, since it was based on native plants. Nevertheless, several of the American plants, as the coconut palm, the sweet potato, the bottle-gourd, the yam-bean, and the upland species of cotton, appear to have been cultivated in the Pacific islands and the Malay region long before the period of discovery by Europeans. Civilization being an outgrowth of agriculture, evidence from the cultivated plants seems pertinent.

The *maho*, or *mahoe*, to use the Jamaican or West Indian name

[1] 6: 339. 1916.

that has found its way into dictionaries, is one of the economic plants that appears to have attained a trans-Pacific distribution in prehistoric times. It is a handsome woody shrub or small tree, with large lemon-yellow flowers, a member of the mallow family, a relative of the cotton plant, the okra, and the hollyhock. The leaves are entire and broadly cordate, much like those of the linden or basswood, a similarity recognized in the name given by Linnaeus, *Hibiscus tiliaceus*, or linden hibiscus. Some writers have called it lemon hibiscus and others corkwood. Many botanists have treated the maho as representing a genus distinct from Hibiscus under the name Paritium, though as originally proposed the genus was called Pariti, one of the East Indian vernacular names being adopted by Adanson as the generic designation.

A SOURCE OF FIBER AND FIRE

Among the early Polynesians the maho must have been a very important plant, since it affords two indispensable materials and has many incidental uses. The bark contains a strong, flexible fiber adapted to many purposes, tying and binding, building houses and boats, snaring or trapping game, and making bark cloths, nets, mats, baskets, and other equipment of primitive life. The wood of the maho has the peculiarity of readily producing fire by friction. The ease with which the natives of Tahiti were able to produce fire from maho wood is remarked by Darwin in the *Voyage of the Beagle*:

> A light was procured by rubbing a blunt-pointed stick in a groove made in another, as if with intention of deepening it, until by the friction the dust became ignited. A peculiarly white and very light wood (the *Hibiscus tiliaceus*) is alone used for this purpose; it is the same which serves for poles to carry any burden, and for the floating outriggers to their canoes. The fire was produced in a few seconds; but to a person who does not understand the art it requires, as I found, the greatest exertion; but at last, to my great pride, I succeeded in igniting the dust.

The heart-wood of the maho is described in Gill's *Jotting: in the Pacific* as very tough and durable, fragrant, of a very dark-

green color, and well adapted for making paddles and the framework of boats and houses. Gill states that most of the firewood used in the islands is furnished by this tree, and also claims for it an important function in agriculture:

> Perhaps the greatest blessing conferred upon these islanders by this tree is its power of renewing the fertility of the soil. Nothing exhausts the soil so speedily as yams or cotton. In ten or twelve years the soil is utterly impoverished. The native plan then is to allow it to be overrun with lemon hibiscus bush. When the timber has become heavy you may be sure the soil is perfectly renewed. The soil which once was dry and hard is now light and extremely rich.

Such a possibility of reclaiming abandoned lands might prove of practical importance in many tropical countries, and would doubtless facilitate the commercial cultivation of the maho as a fiber or paper plant, which has been suggested.

A WILD PLANT IN AMERICA

As with the coconut palm and the sweet potato, the maho figures more prominently among the Polynesians than among the natives of tropical America, although the American origin of the plant is even more clearly indicated. While the coconut and the sweet potato are not known to exist in a truly wild state, the maho is an abundant or even a dominant species in many localities, all the way from Porto Rico and southern Florida to the banks of the Guayaquil River, on the Pacific coast of South America. Although used in the same ways as in the East Indies, for bark cloth and cordage, and for kindling fire, as indicated by Oviedo, Dampier, Sloane, Barrerre, and many later writers, these uses were shared with many other plants, so that no special prominence was attained by the maho. Sloane's *History of Jamaica* states that the outer layers of the bark were used for making ropes and the inner for clothing the slaves.

A CULTIVATED PLANT IN THE OLD WORLD

In the Pacific islands and in eastern Asia the status of the maho was notably different from that in America. Lack of other materials may have enhanced its importance. The making of

bark cloth was a much more highly developed art among the Polynesians than in America. The maho cordage was used especially for making canoes, its strength and durability not being affected by exposure to water. The plant was grown regularly from cuttings, and in some parts of the East Indies a condition of seedlessness appears to have been reached, as with other species that have been subject to vegetative propagation for long periods.

In some of the islands the maho grows spontaneously, and covers large areas that have been abandoned after previous cultivation. As a result of extensive studies of plant dispersal in the Pacific islands, Guppy classes the maho with the candlenut as introduced trees which have replaced native forest vegetation. Low banks of tidal rivers are the favorite habitat. Though many botanists have written of the maho as a cosmopolitan seashore plant, its wide dissemination may be due largely to human agency, as with the coconut palm. The distribution in both cases extends over tropical America and the Polynesian area, including the islands and shores of the Pacific and Indian oceans.

DISTRIBUTION OF THE NAME IN AMERICA

The name maho, with many variations, is widely distributed in tropical America, and is applied locally to many other plants. The form usually employed in Spanish books is *majagua* or *mahagua*, in French *mahaut*, *mahoe*, or *mahou*. In Ecuador the maho is said to be called *jagua*. A reduplicated form, *mahou-mahou*, is listed by Martius for the Galibi Indians of Brazil, but the simple form *mahu* is also mentioned in relation to Mahu as a Tupi place name on the Upper Amazon (*Ethnographie*, 512). How far the plant extends up the Amazon is not known. No definitely recognizable equivalent has been recorded in the Quichua language of Peru, but *ahua*, meaning "string" or "thread," *ahuani* to weave, *ahuac* a weaver, and many other terms of textile implication are of possible interest for comparison with Hawaiian words of similar sound and meaning.

The chief center of popularity for *majagua* as a plant name is in the West Indies. Oviedo, who appears to have written the first account of the plant in Santo Domingo, early in the sixteenth century, called it *demmahagua* and it is still called *demajagua* and *emahagua* in Porto Rico. In de la Maza's dictionary of native Cuban plant names the word *majagua* or its diminutive *majagüilla*, appears in nearly a score of Spanish combinations, *majagua azul*, *majagua blanca*, *majagua de costa*, *majagua hembra*, etc., in application to several genera of *Malvaceae* and *Tiliaceae*, which have fibrous barks, including Hibiscus, Thespesia, Pavonia, Helicteres, and Guazuma. The Porto Rican name of Thespesia is *maga* or *magar*, while *maya* and *maguey* are the native West Indian names of Bromelia and Agave, two other important groups of fiber plants. Several species of Ficus, also with fibrous barks, are called *gagüey*, *jagüey*, or *jagüeicillo*. In Porto Rico *yagua* is the name of the leathery, fibrous leaf-bases of the royal palm.

The list of Mexican plant names by Ramirez and Alcocer includes *majagua* as the name of *Hibiscus tiliaceus* and *Hampea integerrima*, and also *mahahua*, *masahua*, and *majagüilla*, as names of the maho or of Helicteres, Heliocarpus, and Thespesia.

Maho names collected by Pittier from seven of the native languages of Costa Rica apparently have no relation to the West Indian and South American series of maho words, as may be seen from the following list: Bribri, *stsá;* Brunka, *kró-kua*, or *krók-ua;* Térraba, *kip-kuó* and *tro-kró;* Dorasque Gualaca, *kis;* Dorasque Chánguina, *i-lak;* Cuna, *Chagua tupú;* Guaymi, *kó* and *kuá-tá*. Two more aberrant names, *choucoron* and *guimauve*, are listed in Van Wijk's *Dictionary of Plant Names*, probably from Guiana.

OTHER PLANTS CALLED MAHOE IN AMERICA

Among the plants that share the name, or that have been confused locally with the *maho* elsewhere in the West Indies are *Thespesia populnea*, *Hibiscus clypeatus*, and *Sterculia caribaea*. In French Guiana and Brazil the names *mahoe cochon*, *mahaguo*

de playa and *mahaujo* are applied respectively to *Sterculia pruriens*, *Helicteres baruensis*, and *Muntingia calabura*. The last is called *majaguilla* in Venezuela, according to Ernst, who also gives *mijagua* as a name of *Anacardium rhinocarpus*. Gomez de la Maza gives *macagua* as a Cuban name of *Pseudolmedia* and *majagüin* for Pavonia. All these trees have fibrous barks that can be used for the same purposes as the maho bark. Muntingia is very widely distributed and may be considered as replacing the maho in the drier or more elevated regions of tropical America. A Quichua name for tough-barked trees is *p-hancho* or *pjancho*. Muntingia is called *ccarapjancho* in the lower Urubamba Valley, while a species of Heliocarpus is known as *llaosapjancho*.

From Colombia the names *mamagua* and *maragua* have been recorded by Pittier,[2] in relation to another fibrous-barked tree of the mulberry family, *Inophloeum armatum*. In Costa Rica and Panama, according to Pittier, the name *majagua* is not applied especially to the maho tree or its bark, but to any kind of tough bark that can be used for tying. Yet *majagüita* is given as the Costa Rican name of *Pavonia dasypetala*, a plant that furnishes a very tough fiber used by the Indians.

NAMES OF THE MAHO IN POLYNESIA

The tendency in many of the island languages is to suppress the consonants and reduce words to monosyllables, but when the simplified Polynesian names of the maho (*mao*, *mau*, *au*, *hau*, *fau*, and *vau*, are brought together, the essential unity of the series is apparent. For the tree itself the nearest approach in Polynesia to American forms of the name is *moaua*, recorded from Easter Island, or *marau*, from New Guinea, but *mahu*, *mahui*, *mahoe*, *mahaga*, *mahini*, *mahae*, *maoa*, *maharo*, *mahore*, *magoe*, *mageo*, *malo*, and many similar words, relate to the operations of peeling, spreading, pounding, or rubbing the bark, to bark cloth, or to ropes, strings, or strips of bark used in tying or snaring, or in other ways that connect naturally with the maho.

[2] Journ. Wash. Acad. Sci. 6: 114. 1916.

Although little can be inferred with confidence from single instances, the Polynesian maho vocabulary includes several rather prominent groups of words, as the examples will show. Many other words that may prove to be compounds or derivatives of maho names are to be found in the vocabularies of Tregear, Andrews, Pratt, and Churchill.

In suggesting that the Polynesian *hau* and *fau* probably came from a root meaning to "bind or tie up," Christian is in accord with a custom of philologists to deduce particular names from words of more general meaning, but primitive languages, though usually rich in specific names, may lack generic terms, which are a later development. Thus a language having many names for different kinds of spiders and different kinds of plants may still have no terms to include all spiders or all plants, so that such names as *spider-wort* or *bind-weed* are impossible. Even the Spanish could not have *bind-weed*, there being no proper equivalent of *weed*, as representing a class of plants that infest cultivated lands and interfere with the growth of crops.

The question whether *fau* refers primarily to the tree or to the act of using the bark is raised by Churchill:[3]

> In the utter absence of perspective in which these languages appear before us it would be idle to engage upon the attempt to discover whether in sense the tree or the act of using its bast is primordial. In the records before us the stem carries the tree sense without the verb in the Paumotu, the Marquesas, Nukuoro, and Aneityum; nowhere the verb where the noun does not designate a plant which yields a string.

It seems not impossible, however, that orientation in such matters may be improved by taking account of the origins, distributions, names, and uses of the agricultural and economic plants. Churchill has collected linguistic evidence of Polynesian migrations from west to east. That such migrations took place may also be inferred from the cultivation of Malayan and Asiatic plants in all of the islands, but the possession of American plants by the early Polynesian has also to be recognized and explained.

[3] Polynesian Wanderings, 328.

POLYNESIAN COGNATES RELATING TO FIBERS

That a root word associated with the idea of ying or binding may be very prolific in derived forms and meanings is apparent from such a series as our English band, bend, bind, bond, bound, boundary, bundle, etc. A more recently developed analogy is that of our word *wire*, now used not only as the name of fibers or cords made of metal, but also to designate the many different uses to which such material can be put, from fastening things together to sending telegrams. Corresponding series of words appear to have developed in the Pacific archipelagoes from such an original as *maho* or *mahagua*, in connection with each of the principal uses and activities connected with this tree.

In Hawaii *mahui* means to join, unite, adhere to, or imitate; *hoo-mau* is to tie on, or to fit, as sandals or shoes; *maunu*, anything that affords a hold on a person for purposes of witchcraft; *haua* and *kauhau*, to strike, to whip, chastise, or apply stripes; *auau*, a snare for catching and killing birds; *kau*, to catch, hang up, suspend; *kauo*, to drag or haul; *kaula*, a rope or strong cord, a tendon or bowstring. In Easter Island *mahetu* means twisted, like bark for rope; *mahani*, a habit, custom, or practice; and *hakamahani*, to tame, or keep tied, *haka* being a causative prefix; *hai* is to tie up; *hahai*, a package or bundle; *hahie*, firewood; *magoe* and *hahamageo*, to splice or tie together; and *hakamaga*, a roof, which primitive builders usually tie on with strips of bark. In Samoa *fau* is not only the name for the maho shrub and of string or bark used in tying, but is also the verb to tie, or to build by tying the timbers of a house together; *afauto* is the rope along the top of a fishing net; *fafau* is to lash on, to fasten with sinnet, as an adz to its handle, or an outrigger to a canoe; *faufau*, to fasten on, to tie together; *afaga*, the bandage put on the feet when climbing the coconut tree; *faufili*, a cord used by women to fasten on their burdens; and many other compounds given by Pratt.

Easter Island shares with Tonga and New Zealand such words as *mahaga*, *mehaga*, and *mahanga*, relating to nooses in ropes, snares, baits, or allurements for taking game or fish. A Samoan

name for rope is *maea*, while *maa* is a sling in Tahiti. In Paumotu *maka* is a sling, *hakamau* is to thread, join, or assure; *fakamau*, to sustain; *mau*, solid or stable; *fakahau*, to reconcile, soothe, or conciliate; *hau*, to rule, reign, or surpass, superior, kingdom, government, order, peace; *haunoho*, to stay or sojourn; *meamau*, sure, safe; *mehara*, to remember, idea, disposition, sense; *mauri*, soul or mind.

POLYNESIAN COGNATES RELATING TO BARK CLOTH

Although the paper-mulberry appears in recent times to have been more prominent than the maho as a source of bark cloth, words relating to bark cloth indicate an earlier dominance of the maho. Three distinct classes of bark-cloth words may be recognized; the first referring to the peeling and spreading of the bark, the second to the beating of the bark to separate the woody material from the fibrous network, and the third class to the finished bark cloth and its uses.

Words of the first class are represented in Hawaii by *mahihi* and *mahole*, to peel off bark from a tree, and *mahola*, to spread out, but *mahole* also means to open wide, exhibit or display, and *maholo* carries such meanings as to inspect or approve, wonder, admiration, beautiful, glorious, or admirable. In Tahiti *mahae* means to tear. *Mahore*, in the dialect of the New Zealand Maoris, means peeled, while *mahora* means to spread out. In Easter Island *maharo* means to spread out, and also to flatter, admire, or glorify. In Paumotu *mahu* is to deliver; *mahoro*, miscarriage or abortion; *pahore*, to peel off or scale; *pahure*, to be skinned; *kihoe pahurehure*, to flay; *papahoro*, to slip; *pagore*, smooth or without hair on the body; *pahere*, to lop, to prune; *pakirotu*, a piece of wood for beating off bark. In Tahiti, according to Tregear, the word *pahere* means to pare off the rind, and in Mangareva *pahore* is to pare, or the peel taken off.

Among the prominent examples of the second class of maho words, those that relate to the beating, softening, and cleaning of the bark, is *hau*, in some islands the name of the tree, in some meaning to tie or unite, in others, to reconcile or rule. But in Hawaii, Tonga, and New Zealand *hau* or *hauhau* carries the idea

of smiting, chopping, attacking, or conquering. *Wao* and *wau* are to scratch or to scrape. Of words more similar to *maho* or *mahagua*, Hawaii affords *maoha*, to rub or chafe; *mahaha*, soft and tough, also applied to a kind of fish and to a variety of taro; *maholehole*, bruised, crushed together; and *maua*, lame, sore, stiff, close or stingy. The Samoan word *maoa* means "to make a chopping or hammering sound," *vau*, *vavau*, and *valu*, to bruise, pound, scrape, grate, or rub down, as taro or arrowroot. In New Zealand, *mahoe* is a small mallet, said to be used for striking the tattooing chisel, but bark cloth was also beaten with mallets. In Paumotu *mihara* is to regret, rue, or repent; *maha*, to sooth; *mahaki* or *maehaki*, to slacken, abate, hinder, or soften; and *pahurehure*, a bruise or contusion. The Mangarevan *tahoa*, "to make papyrus by beating," is evidently connected with the Easter Islanders' *hahoa*, to cut, wound, or hurt.

The third class of bark-cloth words relates to the finished product and its uses. In Easter Island *mahututu* is "bast cloth in the last stages of composition." In Hawaii *aha*, *aho*, and *ahu* have numerous applications in connection with fibers, cords, and mats. *Ahu* in particular is a fine mat, *moena* a coarse mat, and *kapahau* "a fine species of *kapa*" made from the bark of *hau*. In Samoa *auafa* are "the fine mats constituting the wealth of a family;" *fauepa* is "to prepare the fine mats on which a dead chief is laid in state." In Paumotu *vauvau* means mat, rug, carpet, seat; *kaho* or *kao* is cloth or clothing; and *malo* a strip of bark cloth girded about the loins. *Pahorehore* in Paumotu is defined as to smooth out linen, but is similar to several words already mentioned in relation to the preparation of bark cloth.

POLYNESIAN COGNATES RELATING TO FIRE

The importance of the maho in relation to fire is reflected in the fact that the name for the tree in some of the archipelagoes, including Easter Island, is *purau*, that is, fire-*au*, while *tamau* is the word for tinder in Easter Island and Paumotu. A reduplicated form *purao-purau* is recorded from Paumotu; *pura* means phosphorescent; *purero*, to emit, issue, or appear; *purara*,

to diverge or to spread a report, as analogous to the eventual breaking out of a hidden or smouldering fire.

In Samoa *mafu* is to burn, and many Polynesian and Malay words relating to fire might be considered as echoes of the use of the maho for fire-making. *Mahao* was a Hawaiian name for pith, or for soft, rotten wood. In Wallace's list of Malayan fire-names *aow* occurs several times, and is accompanied by many similar words, *aousa*, *hao*, *ahu*, *afu*, *yafu*, *yap*, and *api*, the last also being widely distributed. In Tahiti *aahi* is a rag, wick, or lint for use as tinder; while in Hawaii *ahu* or *aahu* is a bag in which fire materials were carried. Kindling fire by friction is the meaning of *hogi* and *ogi* in Paumotu, and the same islands have *vera*, *viru*, and *viku* as another group of words relating to fire, possibly connected with *veru* a name for cloth, through the use of rags as tinder.

The two sticks of *au* wood used in bringing fire by friction have separate names in Samoa, the stick with the groove *aunaki*, that held in the hand *aulima*, the latter name being applied also to the handle of a tool of any sort. *Siaga*, another Samoan name for "a large stationary stick used in rubbing fire," is like *siapo*, the Samoan name for bark cloth, and *sia* means "to get fire by rubbing one stick on another." A fire-stick is *kounati* in Mangareva and *kauati* in New Zealand, but in Paumotu *kauati* is to make fire by friction. The use of fire in clearing land or of sticks for digging may be reflected in such words as *mahi*, which in Hawaii means to dig the ground for the purpose of planting food. In Paumotu *ahu* means to transplant, and in New Zealand to cultivate. Other uses of the wood for carrying burdens and for floating outriggers of canoes, as mentioned by Darwin in Tahiti, are reflected in such words as *auamo* and *aumaka*, names for burden-sticks in Samoa; *aualа*, the bier of a dead chief; *ama*, an outrigger in Samoa, Hawaii, and Paumotu; *aumafute*, the Samoan name of the wood of the paper-mulberry after the bark is stripped off; *mafuna*, meaning to peel off, also in Samoa. The buds and young shoots of the maho were eaten in times of scarcity by the natives of some of the islands, the living tissues being mucilaginous, like those of okra.

SYNONYMS OF MAHO WORDS

That other kinds of words, unlike *maho* or *mahagua*, share their meanings in some of the islands does not make the parallel series of maho words appear less significant. Other words for bark, skin, or cloth are *kiri*, *kere*, *kero*, *iri*, or *ere*, which may connect also with *gere*, to strip, and *goregore*, peel or rind, in Paumotu. *Kuku* or *tutu* is a widely distributed word for beating or preparing the bark, and in Samoa *tutu* also means to kindle fire. The principal word for bark cloth is *kapa* or *tapa*, which philologists have considered an imitation of the sound of beating the bark, and *tutu* could be derived in the same way.

In Samoa, where there are no k's, *siapo* is the principal name of bark cloth, made from the paper-mulberry, but *sema* is the name of "a red *siapo*," a color which may indicate maho-bark cloth. Bark cloth and fine mats were valuable property among the Samoans and had a collective name, *toga*, and *tolo* is another Samoan word for kindling fire by friction. Nets or cords to make them were called *kupenga* in New Zealand, *kupega* in Mangareva and Paumotu, and *hupena* in Hawaii, the last a curious approximation to the Greek *hyphaino*, to weave, and *hypha*, a thread.

The mallet for beating cloth is called *ike*, *eike*, or *ie*, and similar words mean to strike, defend, choose, select, or send. In addition to this *ike* the Paumotu people have *iku*, to rub, rasp, or to file; *ika*, to make fire by friction of wood; *rotika*, fire; *roroni*, to twist or wring; *rori*, to strangle with a cord; *rorirori*, pliant, flexible, or supple; *rore*, seductive or deluding. In Maori, *rore* is a snare, according to Tregear. The series may belong with the maho words, to which it runs closely parallel.

DERIVATIVE PLANT NAMES IN POLYNESIA

That the maho was an ancient possession of the island people is also to be inferred from the borrowing of its name for other plants, including three prominent cultivated species that undoubtedly were natives of Asia or the Malay region. From the manner of naming these plants it appears that the islanders

must have had previous acquaintance with the maho. In Fiji, according to Seemann, the maho is called *vaudina*, meaning the genuine *vau*, to distinguish it from several other plants called *vau*.

THE NAME OF THE PAPER-MULBERRY

One of the Polynesian namesakes of the maho is the paper-mulberry tree, called in many islands *maute* or *aute*, in Hawaii *waoke*, *wauke*, or *kawauke*, in Mangareva *eute* or *ute*. A practical reason for considering the paper-mulberry a kind of *au* (the suffix *te* meaning another kind) is that it yields bark cloth, and of a finer quality than the maho. In many of the early accounts of the islands the paper-mulberry appears more prominent than the maho, though now it is seldom cultivated and on the heavily forested islands is becoming extinct, as noted by Cheeseman in Rarotonga. It is not a strictly tropical tree, being hardy in the United States, and often escaping from cultivation. It is supposed to be a native of Japan or China rather than of the Malay region. There is a slight resemblance to the maho in habits of growth and general appearance, adult trees having simple oval or cordate leaves, but on young plants and root-sprouts the leaves are deeply notched and divided.

Other names that may belong to the paper-mulberry are *roga* in Paumotu and *roa* in Tahiti, which suggest *toga*, the Samoan name for collections of bark cloth and fine mats. These were valued as property and used as a medium of exchange. The paper-mulberry was also called *tutuga* in Samoa, and a second growth of paper-mulberry *tuapipi*. Seemann gives *ai masi* and *malo* as the native names of the paper-mulberry in Fiji, but *Ficus scabra* is also called *ai masi*, with the explanation that *masi* is derived from a verb *masia*, meaning to scour.

THE NAME OF THE ROSE OF CHINA

The Polynesians also applied the name *aute* to the "rose of China," *Hibiscus rosa sinensis*. In Rarotonga, according to Cheeseman, the maho is *au*, the paper-mulberry *aute*, and Chinese rose *kaute*. Though not at all similar to the paper-mulberry and not used for bark cloth, the rose of China is a close

relative of the maho, with the same kind of large showy flowers which render it a favorite garden shrub among the Polynesians. It was as natural that the rose of China should be called *aute* on account of its flowers as the paper-mulberry on account of its bark, but almost inconceivable that either of the two plants called *aute* should have been named directly from the other. Two Fijian names of the rose of China, *senitoa* or *seniciobia*, show no resemblance to the Polynesian names.

NAMES OF THE SCREW-PINES

Another prominent plant with a name that may have been borrowed from the maho is the Pandanus, or screw-pine, called by the Hawaiians *hala* or *halau* and by the Samoans *fala*, names that may be understood as *hau*-leaf or *fau*-leaf, and that appear proper enough when we take into account the fact that the long narrow leaves of the Pandanus are rich in fiber, and were woven or braided into mats or used in other ways like the bark of the maho or paper-mulberry. From Fiji Seemann reports *voivoi* as a native name of *Pandanus caricosus*, the species that is cultivated for the sake of its fine fiber, and *vaku vaku* for *Freycinetia milnei*, a screw-pine with edible fruit. Another name for Pandanus, possibly cognate with *maho*, is *tima*, in Paumotu, where *mau* means thread or to join. *Timau* may be analogous to *maute*, the name of the paper-mulberry in Easter Island, and is also similar to *tamau*, the word for tinder in Easter Island.

OTHER POLYNESIAN PLANTS WITH MAHO NAMES

In addition to these prominent species, maho names are applied in Polynesia to several other trees or shrubs Thus among the New Zealanders, who did not have the true maho, one of the indigenous trees (*Melicytus ramiflorus*) is called *mahoe*, and the same word is used, according to Tregear, for "a small mallet used for striking the tattooing chisel." *Mahoewai* is another New Zealand tree name, which also means "to spread out," while *mahore* means "peeled."

The Samoans give the name *faupata* to a native plant, *Cypholopus macrocephalus*, related to ramie, used for weaving fine

mats of a sort called *je sina*, second only to the kind called *je toga*, which are made from Pandanus leaves. A Samoan species of *Trama* is called *fau ui*, *fau uta* is another plant name, *fauatagaloa* is "a species of indigenous cotton," and *ma'o* is the "collective name of several trees." One tree is called *ma'oui* and another *mafoa*.

In Hawaii, *mau-a* and *ma'ua* are recorded as plant names, the former as a timber tree and the latter as food in times of scarcity, as also stated of *kemau*, which may refer to the same plant. *Mao* and *hulu hulu* are given by Watt as Hawaiian names of a native wild cotton (*Gossypium tomentosum*). Cotton and okra are called *vau vau* in Fiji, referring no doubt to the fact that these plants resemble the *vau*, this being the Fijian name of the maho. Another close relative of the maho is *Thespesia populnea*, called *mulo mulo* in Fiji, *milo* or *miro* in Samoa. It was considered a sacred tree in Tahiti, and called *toromiro*. In Mangareva *koumiro* is a name of the cotton plant. Cheeseman records a species of Grewia as *auere* in Rarotonga, where *au* is the maho. Another possible cognate is *mamaki*, recorded as the Hawaiian name of a special kind of bark cloth made from *Pipturus albidus*, a bush related to the ramie plant.

Some of the figs or banyan trees of Polynesia also furnished bark cloth and their names may be modified maho-words. In Rarotonga, according to Cheeseman, *aoa* is the name of *Ficus prolixa*, a tree planted to mark boundaries, and as the source of a coarse kind of bark cloth. In Tahiti also *aoa* refers to one of the fig trees and to bark cloth made from it. *Aoa*, *aofafine*, and *aotane* are names of the banyan and other fig trees in Samoa. *Giliau* and *kiliau* are given by Christian as names of the banyan tree in some of the Caroline Islands, where the maho is called *gili fau*. Another species, *Ficus tinctoria*, is called *mati* in Rarotonga and *matti* in Tahiti, names possibly equivalent to *maute* or *aute*, and suggestive also of names of some of the large wild fig trees in Central America, *amate* in Guatemala, and *chilamate* in Costa Rica. In Rheede's *Hortus Malabaricus* two species of figs are called *atty alu* and *ittyalu*.

Still another bark-cloth tree is *Antiaris bennetti*, called *mavu* in Fiji and *mami* in some of the other islands, according to

Seemann. Even the breadfruit tree has a fibrous bark and is sometimes used to make bark cloth. One of several names for breadfruit is *mai*, which could be considered a variant of *mau*, as *fai* replaces *fau* in some of the islands.

Maho words also appear to be used in the general sense of bush or woods, maho thickets being the only forest on some of the smaller islands. Thus in Samoa *la'au* is tree, timber, or firewood; *vao* is bush, *vai vau*, unoccupied land between two villages, and *vaomaoa*, the forest. In Hawaii *wao* is "a wild place," while *mahakea* is jungle or uncultivated land. In the Quichua language of Peru *mahiska* means abandoned and *mahini* to go wild.

MAHO NAMES OF THE WESTERN PACIFIC

In many of the Micronesian islands the names of the maho are compound words, *kili fau, kini fau, gili fau, gili fai, giri fai, gini fai*, probably meaning bark-*fau*, to distinguish from the other applications of the word. Christian states that in Ponape the maho is called *kalau*, while in another island *kalaua* means bark. In Yap the name of the maho is *kal*. In the Paumotu also *kiri* means bark or cloth, equivalent to *ere* among the Hawaiians, and to *iri*, meaning skin.

Christian gives *pa* and *pe* from two of the Caroline Islands. In Siam *po* is a name for a related fibrous-barked shrub, *Hibiscus macrophyllus*. In China *ma* is an ancient name for hemp, represented in writing by an independent radical which appears in many compound names of other plants.

It may be doubted whether names like *vahu, balibago*, and *pago*, used in Fiji, the Philippine Islands, and Guam, also belong to the *maho* series, but relation seems possible in view of intermediate Polynesian forms like *bago*, crooked, *faga*, to bend, and *haga*, to form or to build. In addition to the more prominent Tagalog name *balibágo*, Merrill's *Dictionary of the Native Plant Names of the Philippine Islands* gives *balabágo, malabago, malabayo*, and *raquíndi*, with numerous variants or compounds of *bali* and *bago* as names of other plants. Names reported from Madagascar and neighboring islands, *baro, foulsapate, var, varo, vau, vaur*, appear to connect with the Malay and Polynesian series. Van

Wijk also gives *evonové* as a Gaboon name, the maho being reported from a few localities in West Africa. Three distinct names are recorded by Schumann and Lauterbach in German New Guinea, *daua*, *marau*, and *papalan*, and another form in the Solomon Islands, *dakatako*.

A wide-spread Asiatic name is *bellipata* or *bellipatta*, which has been reported from Singapore, Ceylon, and Bombay. Several other oriental names, *baniá*, *bariá*, *baru*, *beligobel*, *bola*, *bourao*, *chelwa*, *lo*, *surihagas*, *suringas*, *thengben*, and *thingban*, are listed in Watt's *Dictionary of the Economic Products of India*, or in Van Wijk's *Dictionary of Plant Names*. Some of these names probably were borrowed from other fiber-producing species of Hibiscus, several of which are natives of India. The name *pariti* adopted by Adanson from Rheede's *Flora Malabarica*, published in 1686, was also used in the native language to form compound names of several species of Hibiscus and Gossypium.

Many other maho names exist, no doubt, in the languages of Borneo, New Guinea, and other parts of the East Indies, as well as in Tropical America, but these are not likely to alter the general contrast between the very wide distribution of the words that connect with maho or mahagua and the very local distribution of the others.

SUMMARY

The maho, mahagua, or linden hibiscus (*Pariti tiliaceum*) is one of the economic plants to be taken into account in studying the problem of contacts between the inhabitants of tropical America and the Pacific islands, in prehistoric times. Though considered a native of America, the maho appears to have been distributed over the islands and shores of the Pacific and Indian oceans before the arrival of Europeans.

Readiness of propagation and of transportation by cuttings renders this plant well adapted for cultivation and dissemination by primitive peoples. Although human assistance in transportation does not appear to be so definitely required with the maho as with the sweet potato and other plants that are grown from only cuttings, the names of the maho afford almost as

definite indications of human contacts as in the case of *kumara*, a name for sweet potato already known to have been shared by the Pacific Islanders with the Indians of Peru.

The name *maho* or *mahagua*, with numerous local variants, is widely distributed in tropical America and is closely approximated in many of the Pacific islands, in relation either to the plant itself or to its principal uses for fiber, bark cloth, and fire-making. While the genetic relationships of particular words or applications are to be considered as possible rather than as proved, the general coherence of names and uses would seem to justify a thorough philological investigation. One gains an impression of the language being formed *in situ*, as a reflection of familiar objects and activities in the minds of the islanders.

That the primitive Polynesians were in possession of the maho before they became acquainted with similar Asiatic plants may be inferred, in view of the indications that Polynesian names of other important cultivated plants—the paper-mulberry (Papyrius or Broussonetia), the rose of China (*Hibiscus rosa sinensis*), and the screw-pine (Pandanus)—were derived from names of the maho. The making of fire by friction of wood and of cloth by beating the bark of trees with grooved mallets are specialized arts which may have been carried with the maho from America across the tropical regions of the Old World. A plant that enabled primitive man to kindle fire and tie things together must be held to have contributed much to the arts of civilization.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this JOURNAL and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Mining developments and water-power investigations in southeastern Alaska.* THEODORE CHAPIN, H. M. EAKIN and G. H. CANFIELD. U. S. Geological Survey Bulletin 662-B. Pp. 92, with maps, sections, and illustrations. 1917.

Contains short papers on the work of 1916, as follows: *Mining developments in the Ketchikan and Wrangell mining districts*, by THEODORE CHAPIN; *Lode mining in the Juneau gold belt*, by H. M. EAKIN; *Gold placer mining in the Porcupine district*, by H. M. EAKIN; *Water-power investigations in Southeastern Alaska*, by G. H. CANFIELD.

R. W. STONE.

GEOLOGY.—*Mineral springs of Alaska.* GERALD A. WARING, with a chapter on the *Quality of some surface waters*, by RICHARD B. DOLE and ALFRED A. CHAMBERS. U. S. Geological Survey Water-Supply Paper 418. Pp. 109, with 9 plates and 16 figures. 1917.

The report contains a preliminary chapter on the physiography and geology of Alaska by ALFRED H. BROOKS. The mineral springs are grouped for description into hot, carbonated, sulphur, iron, and salt springs, and individual mention is made of most of the 110 springs whose locations are shown on maps accompanying the report. Analyses of a number of the waters are given, and their characters are described briefly in relation to the rock formations through which they issue.

A number of the stream waters of the Territory were also analysed, and their characters are discussed in a separate chapter, by RICHARD B. DOLE and ALFRED A. CHAMBERS. G. A. W.

GEOLOGY.—*The Helderberg limestone of central Pennsylvania.* JOHN B. REESIDE, JR. U. S. Geological Survey Professional Paper 108-K. Pp. 41. 1917.

A study of seven localities in Pennsylvania leads to the following conclusions:

1. The Tonoloway limestone and the Keyser, Coeymans, and New Scotland members of the Helderberg limestone may be traced from Maryland through central Pennsylvania with their respective characteristic lithology and faunas, and the essential equivalents of all are to be found in New Jersey and eastern New York.

2. The Keyser member decreases in thickness northward from Maryland.

3. The Devonian elements in the fauna apparently decrease from Maryland to New Jersey and New York.

4. The suggestion of an unconformity at the top of the Keyser in Maryland is borne out in Pennsylvania by the variations in thickness of the member and the presence of arenaceous material at the base of the Coeymans. R. W. STONE.

GEOLOGY.—*Geologic structure in the Cushing oil and gas field, Oklahoma, and its relation to the oil, gas, and water.* CARL H. BEAL. U. S. Geological Survey Bulletin 658. Pp. 64, with maps, sections, and illustrations. 1917.

The geologic work done in the field has disclosed the following principal facts:

1. The folding of the formations in the Cushing field usually becomes greater with increase of depth, and there are many marked differences in structure among the Layton, Wheeler, and Bartlesville sands and the surface beds.

2. The interval between the Layton and Bartlesville sands is generally greater around the edges of the anticlines than on their crests.

3. The distribution of the bodies of oil, gas, and water indicates that the source of the oil lay west of the Cushing field.

4. In general the oil area in an elongated dome, where folding is simple, extends farther down on the long axes of the anticline or dome than on the steeper sides.

5. The water surfaces on which the oil and gas rest in the different sands are not level but are inclined away from the centers of the anticlinal folds. R. W. STONE.

GEOLOGY.—*The Palestine salt dome, Anderson County, Texas; The Brenham salt dome, Washington and Austin counties, Texas.* OLIVER B. HOPKINS. U. S. Geological Survey Bulletin 661-G. Pp. 28, with maps, sections, and illustration. 1917.

Viewed as a whole the Palestine dome is a quaquaversal fold on whose flanks are highly inclined beds that dip in all directions away from its center but become approximately horizontal within a few miles; the center of the uplift is extensively faulted, mainly in a northeasterly direction, producing an irregular distribution of the Cretaceous beds and a triplication of the outcrop of the Austin chalk.

Such an intensive and highly localized vertical uplift of quaquaversal form could be produced only by vertical thrust from below. The results observed are analogous to those produced by driving a punch into a sheet of cold steel: the effects are entirely local.

The peculiar local nature of salt domes may be due to the effect of dynamic activity at certain points along lines of deformation, aiding in the solution and transportation of salt, gypsum, etc., from deeplying formations, probably Permian, to the position in which they are found.

The highly folded, faulted, and eroded condition of the Palestine dome and the general absence of oil and gas as surface seepages and in shallow wells in this area detract from its oil prospects.

The results of drilling for oil in the Brenham dome have been discouraging, except that they have demonstrated the presence of a salt dome. Suggestions are given regarding further drilling at this dome.

R. W. STONE.

GEOLOGY.—*Oil and gas possibilities of the Hatchetigbee anticline, Alabama.* OLIVER B. HOPKINS. U. S. Geological Survey Bulletin 661-H. Pp. 33, with maps, sections, and illustrations. 1917.

The geological examination of the area shows that a broad, low anticline, the Hatchetigbee anticline, extends from a point north of Jackson, Ala., northwestward across Tombigbee River to the Alabama-Mississippi state line and beyond; that the disturbance of the earth's crust which produced this fold also produced a fault, the Jackson fault; that the Hatchetigbee anticline has in general stronger dips on its southwestern slope than on its northeastern; that two areas along the crest of the fold are particularly favorable, structurally, for the accumulation of oil and gas, and other areas along the crest of the

fold and along the east side of the Jackson fault are also favorable; that the best chances for accumulations of oil are probably in the sands above and below the Selma chalk, which lies from 780 to 2700 feet below the surface along the crest of the anticline; and finally that there are doubtless other areas of favorable structure in the adjoining region where oil and gas may have accumulated if they are present in commercial quantities anywhere in the region.

R. W. STONE

ORNITHOLOGY.—*Washington region [April and May, 1917]*. HARRY C. OBERHOLSER. Bird-Lore **19**: 211–212. 1917.

The months of April and May, 1917, were unusually cold at Washington, D. C., and the resultant spring migration of birds was peculiar. Many species of migrants that appeared in April were ahead of their usual schedule, but many that came in May were very much delayed. A number of birds rare in the District of Columbia, at least during spring, made their appearance, chiefly in May. Conspicuous among these were *Phalacrocorax auritus auritus*, *Larus atricilla*, *Chlidonias nigra surinamensis*, *Hydroprogne caspia*, *Phloeotomus pileatus abieticola*, *Pisobia fuscicollis*, and *Protonotaria citrea*. H. C. O.

ORNITHOLOGY.—*Description of a new subspecies of* Perisoreus obscurus. HARRY C. OBERHOLSER. Proc. Biol. Soc. Washington **30**: 185–188. December 1, 1917.

A new geographic race of the Oregon jay is here described as *Perisoreus obscurus rathbuni*, from Clallam County, Washington. It is darker than either *Perisoreus obscurus obscurus* or *Perisoreus obscurus griseus*, and much more grayish above than the former, with a usually broader whitish nuchal collar. Its geographic distribution is apparently limited to that part of the State of Washington about Puget Sound and the Strait of Juan de Fuca. H. C. O.

ORNITHOLOGY.—*A review of the subspecies of the Leach Petrel* (Oceanodroma leucorhoa (*Vieillot*). HARRY C. OBERHOLSER. Proc. U. S. Nat. Mus. **54**: 165–172. October 19, 1917.

Notwithstanding the considerable attention that has been paid to the petrels of the *Oceanodroma leucorhoa* group, there is evidently something yet to learn concerning these birds. A study of the entire species, with extensive material, leads to the conclusion that three forms are recognizable: *Oceanodroma leucorhoa leucorhoa* (Vieillot),

which breeds in the North Atlantic and North Pacific Ocean; *Oceanodroma leucorhoa beali* Emerson, which breeds from southeastern Alaska to the coast of northern California; and *Oceanodroma leucorhoa kaedingi* Anthony, which occurs off the Pacific coast of Lower California, south to the Revillagigedo Islands, western Mexico. Of these three forms only the first and third are currently considered valid. Furthermore, *Oceanodroma leucorhoa kaedingi* has hitherto been treated as a species, whereas it is but a subspecies of *Oceanodroma leucorhoa*. H. C. O.

ORNITHOLOGY.—*A new subspecies of* Geothlypis beldingi. HARRY C. OBERHOLSER. The Condor **19**: 182–184. December 7, 1917.

A very distinct subspecies of the Belding yellow-throat is here described as *Geothlypis beldingi goldmani*, from San Ignacio, Lower California. It differs from *Geothlypis beldingi beldingi* in its much duller and less yellowish upper parts, whitish instead of yellowish area on the crown behind the black mask, and more restricted yellow of lower surface. Its breeding range is confined to central Lower California, although a single specimen indicates its wintering in the Cape San Lucas region. H. C. O.

ORNITHOLOGY.—*A remarkable martin roost in the city of Washington*. HARRY C. OBERHOLSER. Bird-Lore **19**: 315–317. December 1, 1917.

Although late summer roosts of the purple martin are by no means uncommon in the eastern United States, there is apparently no record of a martin roost in the District of Columbia prior to 1917. During the latter part of the summer of this year great numbers of the purple martin (*Progne subis subis*) gathered nightly in the Mall, along Fourth Street, where they roosted in the trees along the street-car line. The birds were first noted here on August 5 and continued nightly to resort to this roost until September 9. The number of birds ranged from about 2500 to about 12,000, but the usual number was between 7000 and 8000. They assembled daily about 25 or 30 minutes before sunset and were all at rest in the trees by from 12 to 30 minutes after sunset. Their evolutions during this period were of much interest. During the martin occupation this roost regularly housed also between 100 and 500 European starlings (*Sturnus vulgaris vulgaris*), from 1000 to 4000 purple grackles (*Quiscalus quiscula quiscula*); also, on a few days, a number of bank swallows (*Riparia riparia riparia*) and rough-winged swallows (*Stelgidopteryx serripennis serripennis*). H. C. O.

ORNITHOLOGY.—*Notes on North American birds. III.* HARRY C. OBERHOLSER. The Auk **34**: 465–470. October, 1917.

This paper contains technical notes on two genera and three species. The genus *Bannermania* Mathews and Iredale, recently proposed for the reception of *Oceanodroma hornbyi* (Gray), proves on examination of further material to be invalid, since the characters given in the original diagnosis are not constant. The name of the species should therefore remain *Oceanodroma hornbyi*.

The subgenus *Cymochorea* Coues, recently raised to generic rank by Mathews and Iredale, seems not to be worthy of this elevation. A careful examination of the species of *Oceanodroma* discloses the fact that there are no constant structural differences between them, and that consequently all must be included in the same genus. In view of this, *Cymochorea* Coues can be considered of nothing more than subgeneric rank.

A new subspecies of booby (*Sula dactylatra californica*), recently described by Dr. Walter Rothschild from San Benedicto Island, in the Revillagigedo group, western Mexico, although said to be from California, has apparently never been taken within the confines of that State, and therefore must be excluded from the list of North American birds.

The name *Fregata aquila* Linnaeus, currently applied to the North American frigate bird, has been shown by Mathews to be applicable only to the bird of Ascension Island in the South Atlantic Ocean. The frigate birds of North America now prove to belong to two other species: that of the West Indies and southeastern United States being *Fregata magnificens rothschildi* Mathews, and the Pacific bird, *Fregata minor palmerstoni* (Gmelin).

The name *Strix wapacuthu* Gmelin, recently revived for the Arctic horned owl (the *Bubo arcticus* of Swainson), is now shown, as contended previously by Mr. Brewster, to be applicable only to *Nyctea nyctea*, and thus unavailable for the other species, which should therefore still be called *Bubo virginianus subarcticus* Hoy. H. C. O.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

The meeting of the Board of Managers on February 18, 1918, was devoted chiefly to the discussion and amendment of the report of a special committee on membership policy. The Board adopted rules for the guidance of the Committee on Membership, limiting the resident membership of the ACADEMY to 20 per cent of the active scientific population of Washington, as represented by the number of names in the "Red Book" (the biennial directory of the ACADEMY and its affiliated societies). The requirements for admission to membership, which are stated only in general terms in the By-Laws of the ACADEMY, were more exactly defined by the Board; the principal qualifications adopted is that "the nominee shall have attained recognition for original and meritorious scientific investigation."

ROBERT B. SOSMAN, *Corresponding Secretary.*

BIOLOGICAL SOCIETY OF WASHINGTON

The 578th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, January 26, 1918; called to order at 8 p.m. by President ROSE; 62 persons present.

On recommendation of the Council, J. B. NORTON and S. F. BLAKE, both of the Department of Agriculture, were elected to membership.

On recommendation of the Council a proposed amendment to the constitution was announced by which members of the Society might become life members upon the payment of fifty dollars in two annual installments of twenty-five dollars each.

Under the heading brief notes and exhibition of specimens the following informal communications were presented:

A. WETMORE remarked on food habits of grackle with reference to eating and cracking pin-oak acorns, the peculiar structure of the bill of the genus *Quisqualus* being specially adapted for this purpose. This was discussed by Messrs. PAUL BARTSCH, VERNON BAILEY, and F. V. COVILLE.

A. S. HITCHCOCK called attention to a recently issued flora of the Rocky Mountains by P. A. Rydberg, in which 6000 species of plants of that region are described.

PAUL BARTSCH referred to a recently received collection of Philippine shells from the island of Luzon, containing an unusually large number of new forms.

L. O. HOWARD referred to the utilization of acorns for the manufacture of alcohol.

W. L. McAtee described the behavior of ducks, geese, bitterns, jacksnipe, and kingfishers in North Carolina during the recent continued cold weather; the kingfishers' activities being confined to the vicinity of spring holes.

The regular program of the evening was as follows:

Emerson Stringham: *Notes on the speed of fishes, especially the alewife.* Mr. Stringham said the question of the speed with which fish swim has elements which, it would seem, might make it popular, but there appear to be few recorded observations. It becomes of economic importance in connection with the effect of water power development on the fisheries.

Three preliminary points should be mentioned. In the first place some fish, besides swimming, are able to jump from the water and by this means pass over a current which it would be wholly impossible for them to swim through; we are not concerned here with that question. Secondly, it is assumed that if a fish can maintain itself against a steady current of so many miles an hour, it can swim the same number of miles an hour in still water. Thirdly the velocity of a stream is much less at the bottom or behind obstacles than at surface.

A Belgian engineer (G. Denil), while studying fishways, concluded that the salmon could swim at a speed of 3.15 meters a second for at least 14 meters. The author also refers to similar figures given by a French engineer. In a report on the obstructed condition of the Frazer River published in the Report of the British Columbia Commissioner of Fisheries for 1913, the author (G. P. Napier) expresses the opinion that the limiting velocity of a steady stream up which a sockeye salmon is apparently capable of swimming a very short distance lies between six and seven miles an hour. Mr. H. von Bayer, of the Bureau of Fisheries, published a paper on fishways in 1910, in which he said that the current velocity in fishways should not exceed 10 feet per second. It is remarkable that the three figures, which appear to be independent of each other, are almost identical. The Belgian estimate is about 6.9 miles an hour, the Canadian's is 6 to 7 miles an hour and the American's is 6.8 miles an hour.

In the spring of 1917 Mr. Stringham had an opportunity to study several fishways in Massachusetts, and to make some observations on the velocities of water up which the fish swam. These fish belonged to the species *Pomolobus pseudoharendus* (Wilson), one of the common alewives. The instrument used to measure the velocity of the water was a Price current meter lent by the Bureau of Standards. Measurements were made of the rate of flow at 7 points in the fishway where the current appeared to be greatest, and it was found to vary from 4 to 5 feet per second. At Middleboro the fish were unable to ascend a little sloping falls where the velocity was about 11 feet per second. Just below they were swimming through one place where the current was 5.3 feet per second. At East Warham the head of water, and therefore the velocity could be varied. The fish swam up a slope about 3

feet long where the water was going down at rates of 6.1, 7.8, and even 9.8 feet per second. They were perfectly helpless when it was raised to 13.5 feet per second.

These figures show that for a few feet at least this species can swim through water flowing about 10 feet per second. That is the same figure suggested for the salmon by two different investigators and is the limit suggested for fishways by a third.

The paper was discussed by WILLIAM PALMER, A. N. CAUDELL, VERNON BAILEY, PAUL BARTSCH, H. M. SMITH, E. A. GOLDMAN, and R. W. SHUFELDT.

W. E. SAFFORD: *Natural history of Paradise Key, Florida.*

Mr. Safford's paper was illustrated by numerous lantern slides and is to be published in the Annual Report of the Smithsonian Institution.

M. W. LYON, JR., *Recording Secretary.*

ENTOMOLOGICAL SOCIETY OF WASHINGTON

The 309th regular meeting of the Society was held at the Saengerbund Hall, January 4, 1918; called to order by President SASSCER; 26 members and 10 visitors were present.

A resolution was adopted providing for a permanent entertainment fund to be administered by an Entertainment Committee appointed by the Executive Committee.

Articles III (Members) and VII (Fees) of the Constitution were amended.

The regular program consisted of the address of the retiring President, Prof. C. R. ELY, upon *Recent entomological chemistry.* This interesting review of literature called forth considerable discussion, participated in by Messrs. MIDDLETON, SASSCER, G. G. AINSLIE, WOGLUM, BAKER, WOOD, and BISHOP.

At the close of this discussion the Society was entertained by some brief remarks from two of our visitors, Prof. A. L. LOVETT, of the Oregon Agricultural College, and Mr. R. H. ALLEN, of Massachusetts.

Mr. PAINE exhibited some interesting photographs made under artificial light.

The 310th meeting of the Society was held at the Cosmos Club, February 7, 1918; called to order by the PRESIDENT; 29 members and 9 visitors were present.

The annual report of corresponding-secretary-treasurer was accepted. The corresponding secretary announced the following changes in the publication of the Proceedings: The Proceedings will appear in nine numbers per year instead of four, and will carry advertising. The cover will be printed on the same kind of paper as the text, the seal omitted, and in the space now occupied by the seal will appear the table of contents. Each page will carry a running head which will constitute a complete citation, and the printing of the list of members present at meetings as well as all business transacted at the meetings will

be discontinued. Other minor changes looking to the improvement of the publication will also be made.

Dr. CARLOS E. PORTER, of Santiago, Chile, and Mr. ROBERT M. FOUTS, of Washington, D. C., were elected to membership.

The regular program was as follows:

C. L. MARLATT: *Notes on the work of the Federal Horticultural Board.* Mr. Marlatt gave a very comprehensive account of the organization, purposes, and scope of the services of the Board.

In discussing Mr. Marlatt's remarks, Dr. L. O. HOWARD gave a very interesting account of the events and causes which led to the passage of the Plant Quarantine Act.

CARL HEINRICK: *On the Lepidopterous Genus Apostega and its larval affinities.* The author illustrated his remarks with a number of charts and drawings. This communication drew forth considerable discussion, participated in by Messrs. MCINDOO, PIERCE, ROHWER, BAKER, BOVING, CRAIGHEAD, and HYSLOP.

Under the head of short notes:

Dr. HOWARD announced the recent death of an early member of the Society, Mr. CHAS. R. DODGE. Mr. SCHWARZ also gave a few reminiscences of Mr. Dodge.

Mr. SNYDER called attention to a recent article entitled *Origin of castes in termites* by Dr. C. B. Thompson, of Wellesley College, published in the *Journal of Morphology*. Mr. Snyder spoke very highly of the paper, as did also Messrs. BAKER and HOWARD.

Mr. SNODGRASS expressed his pleasure at the evident interest manifested and progress being made in the study of insect anatomy. Messrs. HOWARD, CAUDELL, and CRAIGHEAD gave additional remarks along the same line.

Dr. T. J. HEADLEY, of New Jersey, responded to the president's invitation to address the Society by giving some interesting reminiscences from his experiences.

Mr. J. G. SANDERS, of Harrisburg, Pennsylvania, responding to a similar invitation, gave an interesting account of some of his experiences since leaving the Bureau of Entomology to go to Wisconsin and later to Pennsylvania. He gave an especially interesting account of some recent researches in Pennsylvania on the life history of the Angoumois grain moth.

A. B. GAHAN, *Recording Secretary.*

PHILOSOPHICAL SOCIETY OF WASHINGTON

The 799th meeting was held at the Cosmos Club, January 19, 1918, with President BURGESS in the chair. There were 45 persons present.

Mr. E. T. WHERRY presented a paper on *Certain relations between optical properties and crystal form, and their bearing on the question of "crystal molecules" in organic compounds.* The refractive indices of several simple organic compounds have been determined by the immersion method, and their values substituted in the Lorentz formula

connecting refractive index and density. The "refraction ratio," or ratio of the several values obtained for each substance, has been compared with the crystallographic axial ratio in each case. In some substances, as urea and iodoform, the two sets of values show exact inverse proportionality, and it is concluded that this indicates that the number of pinacoidal planes in the two crystallographic directions in the crystal molecule, or unit cell of the space lattice, is the same. Others, like oxalic acid, show inverse proportionality in two directions but not in the third, although in the latter a simple integral relation exists. It is concluded that in these the crystal molecule contains different numbers of planes in some directions than in others. In acetamide, which is dimorphous, the planes show somewhat greater divergence in the unstable than in the stable form, suggesting that there is a tendency toward equalization of the number of planes. From these data it is possible to draw conclusions as to the types of space-lattices represented in these substances, without the necessity of submitting them to examination by X-rays.

Discussion: The paper was discussed by Messrs. MERWIN, WHITE, SOSMAN, and BICHOWSKI.

A paper by W. F. MEGGERS and C. G. PETERS on *The refractive index and optical dispersion of air*, was presented by Mr. PETERS. This paper was illustrated by lantern slides. A survey of previous researches on refraction of air shows that most investigators have worked either with white light or with one monochromatic radiation, and dispersion measurements have been limited to a small interval of the spectrum. No index measurements exist for waves longer than those corresponding to orange light, and in the ultra-violet the dispersion formulas disagree by more than 10 per cent of the index of refraction.

Recent work in spectroscopy makes it very desirable to have more accurate and extensive data on the index of refraction and dispersion of air. The international system of standard wave length measurements made under other conditions require small corrections because of the effect of temperature and pressure of the air upon its optical dispersion. Furthermore, it is often desirable to multiply wave lengths measured in air by the indices of refraction of air for these wave lengths and thus convert them to their value in vacuum. An accuracy of one part in several millions is now striven for in the measurement of wave lengths, and to maintain their relative accuracy in the reduction to vacuum values it is necessary to know the indices of refraction to about one unit in the seventh decimal place.

For several years the Bureau of Standards has been engaged in the accurate measurement of wave lengths. Interferometer comparison of wave lengths have been made throughout a large range of spectra and the grating spectra of more than fifty of the chemical elements have been photographed and measured in the red and infra-red spectral regions. In connection with these accurate measurements of wave lengths, it was thought advisable to measure the absolute indices of refraction of air for the entire spectra region that is accessible to photography.

Accuracy and efficiency recommended the use of a interferometer of the Fabry and Perot type for this work, since this apparatus can be conveniently enclosed in a chamber in which the temperature and pressure of the air can be regulated as desired, and it also permits simultaneous observations for a large number of different wave lengths. Sections of the circular fringes, produced by various radiations from a source of light illuminating the parallel plates of the interferometer, were photographed either with a grating or a prism spectrograph, first when the space between the plates was evacuated and then when dry air at measured temperature and pressure was present.

The index of refraction of air for a particular wave length was obtained directly from measurements of the photographed interference fringes, which allowed the ratio of lengths of this wave in vacuum and in air to be calculated. Observations were made at spectrum intervals of about 40 A from the extreme ultra-violet at 2200 A, through the visible spectrum and into the infra-red to 9000 A.

Complete sets of observations were made on dry air at atmospheric pressure and at temperatures of 0°C., 15°C., and 30°C. These are quite well represented by the following dispersion formulae:

$$(n-1)_0 \times 10^7 = 2875.66 + \frac{13.412}{\lambda^2 \times 10^8} + \frac{0.3777}{\lambda^4 \times 10^{16}}$$

$$(n-1)_{15} \times 10^7 = 2726.43 + \frac{12.288}{\lambda^2 \times 10^8} + \frac{0.3555}{\lambda^4 \times 10^{16}}$$

$$(n-1)_{30} \times 10^7 = 2589.72 + \frac{12.259}{\lambda^2 \times 10^8} + \frac{0.2576}{\lambda^4 \times 10^{16}}$$

The coefficient of index variation with temperature was found from these observations to be a function of the wave length. For long waves this optical temperature coefficient is identical with the density temperature coefficient, i.e., $\frac{1}{273}$, but as the ultra-violet absorption band is approached it increases rapidly, becoming $\frac{1}{258}$ at 2500 A.

Discussion: This paper was discussed by Messrs. BURGESS, SWANN, CRITTENDEN, and MEGGERS.

The third paper, on *Barometric ripples*, was presented by W. J. HUMPHREYS. This paper was illustrated by lantern slides. Small pressure changes, amplitude usually 0.1 to 0.3 mm. and period of 5 to 10 minutes, and continuing for hours or even days together, are very common during cold weather.

As first demonstrated by Helmholtz, whenever layers of air that differ in density at their interface flow over each other, long billows, analogous to gravity water waves, are produced, which conform, approximately, to the equation

$$d_1 (u - V)^2 + d_2 (V - v)^2 = \frac{g\lambda (d_2 - d_1)}{2\pi}$$

in which V is the velocity of wave propagation, d_1 and d_2 the densities of the layers whose velocities are u and v respectively, g the gravity acceleration, and λ the wave length. If, now, the under layer is colder than the upper, as often happens during winter, and rather shallow, 100 meters to 500 meters thick, say, the passage of the air billows, like the passage of waves in shallow water, necessarily produces greater or less corresponding changes in the pressure on the bottom layer—changes that appear as a series of ripples in the record of a sensitive barograph. Furthermore, such shallow air billows, like shallow water waves, doubtless are turbulent—a condition that accounts, presumably, for the surprisingly rough flying the aviator often experiences during winter at low levels (300 meters and less).

During summer when air billows rarely form near the surface, though frequently at greater altitudes, especially that of the cirrus cloud, barometric ripples and shallow turbulences of the kind just mentioned seldom occur. This, doubtless, is because wave disturbances in air as in water do not penetrate far beneath the wave level.

Discussion: Mr. LITTLEHALES called attention to the fact that where there are two layers of water of different density, waves frequently occur at the interface that separates the two water layers and yet no waves are visible on the surface. These waves at times are sufficient to impede the progress of vessels. The paper was further discussed by Messrs. WHITE, BURGESS, SWEET, BUCKINGHAM, and SOSMAN.

H. L. CURTIS, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The Honorary Advisory Council for Scientific and Industrial Research of Canada visited Washington on February 25–28. The Council is considering plans for the encouragement of scientific research in Canada, and spent some days in consultation with members of the National Research Council, and in visiting the scientific bureaus of the Government. The visiting members were: Professor A. B. MACALLUM, of the University of Toronto, (chairman); Professor S. F. KIRKPATRICK, of Queen's University, Kingston; Professor R. F. RUTTAN and Professor F. D. ADAMS, of McGill University, Montreal; President A. S. MACKENZIE, of Dalhousie University, Halifax; Mr. ARTHUR SURVEYER, of Montreal; Mr. J. B. CHALLIES, of the Water Power Branch, Department of the Interior, Ottawa, (Honorary Secretary of the Council).

Professor C. A. KOFOID, of the Department of Zoology, University of California, has been commissioned a major in the Sanitary Corps of the National Army, and is stationed at the Department Laboratory, Fort Sam Houston, San Antonio, Texas.

Major R. A. MILLIKAN, member of the National Research Council and Chief of the Science and Research Division of the Signal Corps, has been commissioned a Lieutenant Colonel in the Signal Corps.

In honor of the appointment of Dr. J. W. FEWKES as Chief of the Bureau of American Ethnology, a complimentary luncheon was tendered to him and Mrs. Fewkes at the Smithsonian Institution on Friday, March 1, 1918. Every member of the staff and all the employees of the Bureau were present. At the close of the luncheon Dr. Fewkes made a brief address, recalling the high traditions of the Bureau of Ethnology and outlining plans for its further development. The primary objects of ethnologic research in this country were defined by Dr. Fewkes as, *Man in America,—where did he come from, how long has he been here, and what has he been doing since he came?* Short speeches were made by members of the Bureau, the first speaker being Mr. JAMES MOONEY, who noted that the study of ethnology tends to bind the whole human race together by securing a better understanding of mankind.

The following persons have become members of the ACADEMY since the last issue of the Journal: Mr. LOT A. HAWKINS, Bureau of Plant Industry, Department of Agriculture, Washington, D. C.; Dr. OSCAR RIDDLE, Department of Experimental Evolution of the Carnegie Institution of Washington, Cold Spring Harbor, Long Island, New York; Mr. ERSKINE DOUGLAS WILLIAMSON, Geophysical Laboratory of the Carnegie Institution of Washington, Washington, D. C.